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ORIGINAL ARTICLE

Role of Kinematic Magnetic Resonance Imaging for Evaluation of Cervical Spondylotic Myeloradiculopathy: Diagnostic Accuracy and Surgical Planning

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ABSTRACT

Objective: The dynamic part of cervical spondylotic myeloradiculopathy (CSM) is conventionally being evaluated using static magnetic resonance imaging (MRI), which does not address dynamic changes in flexion and extension of the cervical vertebral column. The objective of the study is to evaluate the utility of kinematic MRI imaging in diagnostic accuracy and surgical planning of evaluation of CSM.

Materials and methods: In a prospective study, 30 patients with CSM were evaluated with conventional standard MR cervical spine and kinematic MRI cervical spine with flexion and extension. Morphometric measurements were compared between neutral, flexion, and extension images.

Results: The cervical cord length and cervical canal length were significantly longer in flexion and significantly shorter in extension in all cervical cord sagittal lines. Flexion was associated with decrease in spinal cord compression in 40% of patients, whereas extension caused increase in compression (increase in the size of T2 hyperintensivity) in 75% of patients. Extension identified new subtle T2 hyperintensities. Interpretation of standard MRI findings and the clinical level of radiculopathy is poor, which improves when the neck is extended.

Conclusion: Our results suggest that integration of kinematic MRI with standard static MRI provides additional information in diagnostic accuracy and surgical planning.

Keywords: Cervical vertebrae, Magnetic resonance imaging, Spinal canal, Spondylosis.

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INTRODUCTION

Cervical spondylotic myelopathy is one of the most common diseases of cervical spine that occurs during and after middle age.[1-4] Cervical spondylosis is a chronic degenerative condition of the cervical spine that is caused by a combination of factors, such as vertebral disc protrusion, osteophyte formation, facet joint degeneration, and hypertrophy of the ligamentum flavum. Both mechanical and dynamic factors are reported to play a role in the pathophysiology of myelopathy.[4,5]

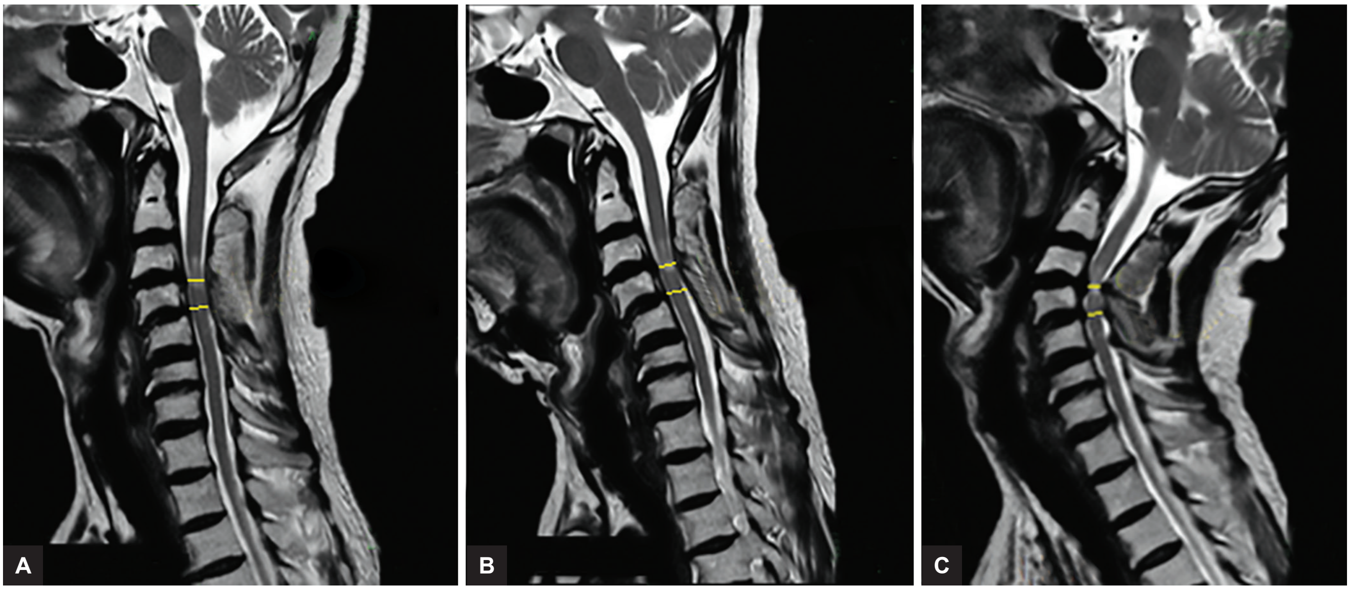
Conventionally, preoperative MRI of the cervical spine is done in neutral position only; however, CSM is a dynamic disease of lifestyle.[5] Kinematic MRI of the cervical spine in flexion and extension positions is not routine in evaluating CSM. Dynamic MRI studies[5,6] have been conducted in a few studies to see changes that occur in the spinal cord during flexion and extension of the cervical spine. However, there is lack of clear data of its utility.

The CSM is a progressive disease that requires immediate surgical intervention to minimize damage to the spinal cord and preserve its function. Surgical options include anterior cervical discectomy and fusion, posterior laminectomy and decompression with or without instrumental stabilization. But the choice of surgery is mostly based on static MRI finding.

This study was conducted to assess the utility of kinematic MRI in CSM. The objective was to assess the morphometric measurements of the cervical spine in patients with CSM in the neutral, 30° flexion, and 30° extension positions and to assess its utility in diagnostic accuracy and surgical planning.

MATERIALS AND METHODS

Following the approval of the Institutional Ethical Board, we conducted a prospective study of 32 patients diagnosed with CSM, during the period from July 2017 to December 2017. All patients met the criteria for CSM.[7,8] Thirty patients were included in the study in whom we could perform 30° neck flexion using a soft roll under occipital protuberance and 30° neck extension using a soft roll below shoulder. Two out of 32 patients were excluded who could not tolerate neck flexion or extension due to



Figs 1A to C: Cervical spine T2 sagittal MRI with manual morphometric measurement. (A) Neutral (C3–C4 = 0.68 cm, C4–C5 = 0.78 cm), (B) flexion (C3–C4 = 0.73 cm, C4–C5 = 0.88 cm), (C) extension (C3–C4 = 0.40 cm, C4–C5 = 0.60 cm)

severe pain; 25 (83.33%) of the patients were male and 5 (16.66%) were female, with an average age of 65 years (42–82 years).

Inclusion Criteria

- A clinical and radiographic diagnosis of CSM
- Patients who could tolerate 30° flexion and extension of neck
- Age greater than 18 years
- Patients who signed informed consent form

Exclusion Criteria

- Patients younger than 18 years
- Patients with previous history of cervical spine surgery
- Patients refusing to participate or to sign the informed consent

All patients underwent an MRI of the cervical spine using the same apparatus (Magnetic Resonance 1.5T, Philips) supervised by primary authors who constantly monitored the patients in order to avoid the occurrence of neurological complications during neck flexion and extension. During the first step, the examination was conducted with the patients in the routine supine position with the neck in the neutral position (Fig. 1A). In the second step, a soft roll was positioned under the patient's occipital protuberance in order to achieve 30° neck flexion (Fig. 1B). In the third step, a soft roll was placed under the patient's shoulders to maintain 30° extension (Fig. 1C); T1 and T2 sagittal, axial, and coronal images were obtained in all positions.

All morphometric measurements were noted in the sagittal and axial T2-weighted MRI sequences of the neutral, flexion, and extension positions. The parameters studied were the anterior length of the spinal cord, the posterior length of the spinal cord, severity of cord compression with 300% magnification in sagittal T2-weighted MRI sequences.[9,10] All the images were analyzed by the primary author using standardized 300% magnification. Anterior and posterior lengths of the spinal cord were calculated by measuring the distance between a straight line at the upper limit of the anterior and posterior arcs of C1 and a straight line along the lower border of body of C7 (Table 1).

Table 1: Details of manual morphometric measurement

ALSC	Anterior length of the spinal cord	Between C1 and C7 is a straight line crossing the spinal cord at the upper edge of the anterior and posterior arcs of C1 and a straight line passing along the lower terminal plate of C7
PLSC	Posterior length of the spinal cord	
DVC	Diameter of the vertebral canal	Shortest distance between the center of the posterior edge of the intervertebral disc of each segment and the anterior edge of the ligamentum flavum posteriorly
DSC	Diameter of the spinal cord	Shortest distance between the anterior and posterior edges of the spinal cord

RESULTS

Two out of 32 patients were excluded who could not tolerate neck flexion or extension due to pain.

Table 2: Summery of result

Findings (n = 30)	*No*	*Percent*	*Treatment offered*
Radiculopathy was present, but neutral MRI showed no cord compression, but extension MRI showed mild compression	5	16.6	Conservative
Increase in cord compression in extension MRI (Muhle grading/ manual morphometric measurement)	25	76.66	Anterior cervical discectomy and fusion
Increase in/ appearance of new T2 hyperintensities	12	40	Anterior cervical discectomy and fusion
Multiple-level cord compression	2	6.6	Posterior decompression

The average anterior length of spinal cord was significantly longer in flexion than in extension, and shorter in extension in all cervical cord sagittal lines (p = 0.002).

Flexion was associated with a decrease in spinal cord compression in 90% of patients, whereas extension caused an increase in compression in all patients. Extension identified new T2 hyperintensities, suggestive of increase in cord compression with neck extension.

In 5 (16.66%) patients, severe radiculopathy was present, but neutral MRI showed no cord compression, but extension MRI showed nerve root compression, which could explain the cause of radiculopathy; all these patients were treated conservatively with pharmacological drugs, regular physiotherapy, and regular follow-up. In 25 (76.66%) patients, extension MRI showed an increase in cord compression, and out of these, 12 patients showed an increase in T2 hyperintensity signal changes. All these patients were treated with surgery—anterior cervical discectomy and fusion with polyetheretherketone cage. Two patients showed multiple-level cord compression with appearance of new T2 hyperintensities in extention as compared with neutral; these patients were treated with surgery—laminectomy, posterior decompression, and stabilization with instruments (Table 2).

DISCUSSION

Our study findings show that CSM is a dynamic disease and the degree of cord compression varies with the position of the neck.

In all the patients in this study, the lengths of the spinal cord and severity of cervical cord compression were more in flexion than in neutral, and least in extension positions than neutral.

Extension of neck was associated with worsening of compression, prominence of T2 hyperintensity signals, and appearance of new T2 hyperintensity signals, which helped in planning the surgical strategy/approach—anterior *vs* posterior.

In some patients with radiculopathy, extension MRI helped in identification of nerve root compression, which could explain the cause of radiculopathy which could not be explained by conventional static MRI.

Our study has its limitations, such as the small number of patients evaluated, but the morphometric measurements can be reproduced in larger studies in future to investigate the role of kinematic MRI in evaluating patients with CSM.

CONCLUSION

Our results showed that kinematic MRI cervical spine primarily using flexion and extension of neck is very useful in diagnostic accuracy and surgical planning in CSM as compared with conventional static MRI.

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